

Remarks

Applicant gratefully acknowledges the helpful suggestions provided by the Examiner. In accordance with those suggestions claims 58 and 69 have been amended to recite microelectromechanical devices, and claims 59 and 70 have been amended to replace “miniature electromechanical” with --microelectromechanical--. As noted by the Examiner, the accepted nomenclature for MEMS is microelectromechanical system.

In like manner, on page 3 of the specification in the paragraph of the “Detailed Description of the Invention,” the paragraph has been amended to replace “miniature electromechanical” with --microelectromechanical-- . Support for this amendment may be found in *An Introduction to Microelectromechanical Systems Engineering*, pp. xvi, Nadim Maluf, Norwood, MA, Artech House, 2000, a copy of which is enclosed.

Claim 62 has been amended to limit the metals melted on the contact pads to metals selected from a group consisting of aluminum, copper, gold, silver and alloys comprising these metals. Support for this amendment may be found in the specification, page 7, lines 14-23. Claim 62 was rejected over Mackay et al., U.S. Patent 6,293,451. Mackay et al. describe forming solder balls on contact pads, melting the solder which cools to spherical shapes on the contact pads and there is no teaching or suggestion in Mackay et al. to use aluminum, copper, gold, silver and their alloys. Chen et al., U.S. Patent 6,063,647, col. 4, lines 13-23 and 44-48, describe circuit elements of dielectrics that support a circuit network. The circuit elements include flexible circuits, printed circuit boards, chips, and dies, and are typically polyimide foil. Chen et al. col. 5, lines 26-29, suggest as metal for the bumps tin, aluminum, indium, lead, gold, silver, bismuth, copper, palladium and the like and alloys of these materials. The melting points of

aluminum, gold, silver, copper and palladium are 659°C, 1063°C, 961°C, 1083°C and 1555°C respectively. Heating the substrates, i.e. circuit elements, of Chen et al. to these temperatures in order to melt these metals and form bumps would destroy the substrates. Therefore applicant respectfully submits that Chen et al. teach away from applicant's invention, and one of ordinary skill in the art would not attempt to modify the method of MacKay et al. and Capote et al. to form bumps of aluminum, copper, gold, silver and alloys comprising these metals.

Although Chen et al. prefer spherical-shaped bumps, other shapes are permissible, col.5, lines 11-14. The bumps of Chen et al. are formed on the circuit element by conventional deposition techniques, col. 5, line 25; Chen et al. are silent on methods of depositing the preferably spherical-shaped bumps. Therefore applicant respectfully submits that Chen et al. do not teach or suggest applicant's method of melting aluminum, copper, gold, silver or alloys of these metals to obtain convex bumps on the contact pads of insulating substrates.

Claim 63 was rejected over MacKay et al. who have described the solder as being deposited by electroplating. Claim 63, dependent on amended claim 62, does not cover solder deposition, it is limited to depositing aluminum, copper, gold, silver or alloys of these metals. Therefore applicant respectfully request that the rejection of claims 63 over MacKay et al. be withdrawn.

Claims 66-68 have been amended to limit the metals deposited to form the protuberances to the group consisting of aluminum, copper, gold, silver or alloys of these metals. Claim 66 has also been amended to delete a typographical error, "a" at the end of line 11 of the claim. Claim 66 was rejected over MacKay et al. and Capote et al. Applicant respectfully submits that the

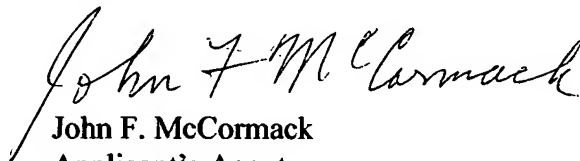
subject matter of claims 66-68 as now amended is not suggested by MacKay et al. and Capote et al.

Claim 71 has been amended to depend on claim 65 so that is now covers depositing copper by printing a paste of a copper powder in an organic vehicle; drying the copper paste deposits; heating the copper paste deposits at a temperature sufficient to destroy the organic vehicle, melting the copper deposits, whereupon melting, the copper deposits form shapes of convex copper protuberances on the metallic contact pads, and then cooling the copper protuberances. Support for this amendment may be found in the original specification on page 10, lines 4-10.

Claims 54-57, 60 and 61 previously had been allowed.

Applicant respectfully submits that claims 58, 59 and 62-71 as now amended describe novel, useful manufacturing methods, and applicant respectfully requests early allowance.

Respectfully submitted


John F. McCormack
Applicant's Agent
Reg. No. 30474

John McComack
116 Milburn La
Roslyn Heights, NY 11577
Tel.: (516)621-7830

BEST AVAILABLE COPY

**An Introduction to
Microelectromechanical
Systems Engineering**

Nadim Maluf



Artech House
Boston • London

For a listing of recent titles in the *Artech House Microelectromechanical
Systems Library*, turn to the back of this book.

Library of Congress Cataloging-in-Publication Data

Maluf, Nadim.
An introduction to microelectromechanical systems engineering
/ Nadim Maluf.

p. cm. — (Artech House MEMS library)

Includes bibliographical references and index.

ISBN 0-89006-581-0 (alk. paper)

1. Microelectromechanical systems. I. Title. II. Series.

TK7875 .M35 2000

621.381—dc21

99-052406

CIP

British Library Cataloguing in Publication Data

Maluf, Nadim

An introduction to microelectromechanical systems —

(Artech House MEMS library)

1. Microelectromechanical systems

I. Title

621.3'81

ISBN 0-89006-581-0

Cover design by Lynda Fishbourne. Cover illustration by Jerry Gist.

© 2000 ARTECH HOUSE, INC.

685 Canton Street

Norwood, MA 02062

All rights reserved. Printed and bound in the United States of America. No part of this book may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher.

All terms mentioned in this book that are known to be trademarks or service marks have been appropriately capitalized. Artech House cannot attest to the accuracy of this information. Use of a term in this book should not be regarded as affecting the validity of any trademark or service mark.

International Standard Book Number: 0-89006-581-0

Library of Congress Catalog Card Number: 99-18034

10 9 8 7 6 5 4 3 2

Preface

A few years ago I stood before an audience at a customer's facility explaining the merits of micromachining technology. The small conference room was packed, and all ears were attentive. Everyone was eager to learn about this mysterious buzzword, "MEMS." Although many in the audience were nodding in a sign of comprehension, the glazed looks on their faces betrayed them. This experience is not unique, but one that is repeated frequently in auditoriums around the world. The technology is simply too broad to be explained in a short lecture. Many technical managers, engineers, scientists, and even engineering students with little or no previous experience in microelectromechanical systems are showing keen interest in learning about this emerging technology. This book is written for those individuals.

In this book I sought to introduce the technology by describing basic fabrication processes and select examples of devices and microsystems that are either commercially available, or show great promise of becoming products in the near future—practical examples from the "real world." The objective is to provide a set of representative cases that can give the reader a global understanding of the technology's foundations, and a sense of its diversity. The text describes the basic operation and fabrication of many devices, along with packaging requirements. Inspired by the adage "a picture is worth a thousand words," I have included numerous descriptive schematic illustrations. It is my hope that scanning these